Towards Multispecies Interaction Environments: Extending Accessibility to Canine Users

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Towards Multispecies Interaction Environments: Extending Accessibility to Canine Users

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ABSTRACT
In this paper we discuss the role of mobility assistance dogs in human society and the challenges they face when operating in human environments. We present the findings of an ethnographic study at a training facility as well as the findings of early evaluations of canine-friendly switches. We discuss how the species-specific implementation of core interaction design principles could inform the design of interaction environments that better support these skilled workers.

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Mobility assistance dogs, interaction design principles, animal-computer interaction, canine accessibility

ACM Classification Keywords
H.5.m. Information interfaces and presentation.

INTRODUCTION

Designing user-centered interactions that can support animals in their activities has been proposed as a core aim of ACI research and practice [16] and, in this respect, service dogs are one of the most represented user groups in ACI [9,27,30]. In particular, mobility assistance dogs carry out a wide variety of tasks on behalf of their assisted humans, but face significant challenges due to the mismatch between their characteristics as users and the characteristics of the environments in which they are required to operate. These challenges affect the dogs' learning process and in time even their welfare.

In human environments, the design of interactive products is underpinned by widely recognized principles in order for them to provide good usability and experience [Preece et al]. While human environments might adhere to these principles from the perspective of human users, this is not the case from the perspective of the mobility assistance dogs who have to learn to negotiate such environments. This lack of user-specific adherence to appropriate design principles leads to the usability and experience challenges that canine workers are faced with on a daily basis.

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In this paper we discuss the importance of interaction design principles to achieve good usability and user experience and how, from a canine perspective, the design of the human interfaces that mobility assistance dogs have to learn to use and then operate daily for years contravenes almost every fundamental design principle. We report on an ethnographic study we carried out at a leading training facility in the UK, to better understand the challenges faced by these dogs, with a particular focus on the example of switches training and operation. We then describe early prototype switches designed with basic interaction design principles and canine characteristics in mind; and we report on the findings of an early, longitudinal field study conducted at a UK University campus, and of an early case of spontaneous adoption for training purposes. Based on our findings and reflecting on sensemaking mechanisms from a multispecies perspective, we discuss the relevance of different interaction design principles. We thus identify a core set of principles, suggesting that their systematic consideration against the sensory, cognitive and physical characteristics of canine (or other) users can inform the development of more accessible *interaction environments*. We envision a multispecies society in which built environments better support all their inhabitants, especially those who are required to perform tasks on behalf of others.

BACKROUND

The role of mobility assistance dogs in society

Since its emergence in the '70s, the concept of mobility assistance dog has been adopted throughout the western world, predominantly in North America and the UK. Nowadays, in the UK alone there are 7 Charities, accredited through Assistance Dogs UK (ADUK) [2] and Assistance Dogs international (ADI) [1], training and providing, free of charge, dogs to assist people with a range of physical disabilities. Typically, waiting lists are between two and four years. so many people with disabilities resort to training their own dogs or employing private trainers to train their dogs in the tasks they need them to perform.

Mobility assistance dogs are trained to undertake the ordinary activities of daily living that people with disabilities may find difficult or impossible (e.g. opening or closing doors, operating light switches, traffic lights or elevators). But, their role is not limited to providing practical help. Stigma, discrimination, disability hate crime, psycho-emotional disablism, poverty and powerlessness are for some people an everyday occurrence [24]. Here the dogs bring additional benefits in their interactions with people with disabilities and wider society, extending their role "*from the ordinary to the extraordinary*" [6]. In an ethnographic study, Camp [3] found that having an assistance dog with them changed the way people with disabilities were perceived by others and in turn how they perceived themselves. Shifting the focus away from their disability, the dogs' presence made people feel less disabled, allowing them to accomplish tasks in partnership with their dogs and independently of others. Participants characterized their relationship with their assistance dog as being of fundamental importance to them, perceiving the dogs as 'closer than family'. Our own findings from an ongoing qualitative study, which explores participants' experiences of using an assistance dog and living with Multiple Sclerosis, highlight the fundamental role the dogs have in their lives. For one example, Jane, 61, says about her dog Abbey: "*…both of us together learnt again to go out and meet people…that just made, just made such a tremendous difference…suddenly when she was qualified and I could go out on my own.*" Jane dreads Abbey's retirement due in 18 months time: "*…suddenly to find I am dependent on this one thing, but the only side effects that belong to an assistance dog are wonderful, it is going to be taken away you know it's, it's difficult, very difficult…*".

The role of assistance dog is highly demanding, so dogs retire around the age of 10, causing considerable emotional distress to their human partner, as highlighted by Jane's comment. Furthermore, it is estimated that as many as 50% of dogs in training fail to qualify in the first place. Although reasons often cited for this are health or behavior, research suggests otherwise. Coppinger *et al.* [4] researched equipment used by disabled people and their assistance dogs, such as tug ropes tied to door handles for the dogs to pull when opening doors. The authors criticized the potential effects on the welfare of the dogs undertaking the tasks and pointed out how several of the tasks that they are required to perform *"...fall outside the normal canine repertoire of internally motivated behaviours*". The authors highlighted how the dogs' tasks are made even harder by the fact that they are unlikely to understand the relation between their action (e.g. pushing a button), its effect (e.g. the elevator arriving) and its purpose (e.g. helping their human move to a different floor). They further suggest that "*...some failures of service dogs are less a problem of inadequate dogs than of the difficulty of the tasks they must perform, and the inadequacy of much of the equipment they are required to perform with, and the instinctive behaviour of the dogs themselves*" [4]. In other words, in spite of their fundamental contribution to society, mobility assistance dogs have to face challenges that for human workers would be deemed objectionable. Below we examine the limitations of the dogs' working environments from an interaction design perspective.

Design principles: fundamentals of interaction design

When developing interactive products, typically interaction designers work towards specific usability (e.g. learnability, efficiency) and user experience (e.g. the extent to which a product is motivating to use or aesthetically pleasing) goals as deemed appropriate for that particular product [23]. Whatever usability and user experience goals may be prioritized for specific products, interaction designers have long recognized the importance of applying interaction design principles [21,28,22,18] that account for the user's sensory, cognitive and physical capabilities. The following principles are most widely recognized [23]. First defined in reference to visually mediated technological interactions [21], the principle of visibility is probably better described as *perceivability*; this is the extent to which the elements of an interface are detectable by the sensory capabilities of the user (e.g. too weak a ringtone may not prompt the user to pick up their phone). The principle of *consistency* [23] applies to the interface organization (e.g. the appearance and distribution of icons across the different pages on a website), both internally (within the same website) and externally (e.g. navigation conventions across similar websites); it also applies to the association between system input and output (e.g. clicking the same icon reliably produces the same outcome each time). *Mapping* is another principle and a different kind of consistency, this time between the representation of a function on an interface and its outcome (e.g. a volume bar on a screen; the longer the bar the higher the volume). *Affordance* [5,22], the extent to which an object's form suggests how it can be interacted with, could also be interpreted as a kind of consistency, between the morphological characteristics of an object and the ergonomic characteristics of the user (e.g. a joystick affords being wrapped around by fingers). On the other hand, *constraints* prevent the user from engaging with an object in ways that are fruitless (e.g. a handle-less door signals the fact that the user should not try to pull it but push it instead). Finally, *feedback* [21,23] is how an interactive system lets the user know what their actions have achieved and is therefore fundamental to support interaction; this is especially important where there is space-temporal distance between the user's input (e.g. clicking a button) and the interaction's outcome (i.e. the resulting effect), so feedback lets the user know in a timely fashion that they have successfully engaged with the system whilst they wait for the outcome of their interaction to become apparent (e.g. to receive the garment they have purchased online).

Although interaction design principles themselves might be regarded as relatively universal, their implementation needs to conform to the specific sensory, cognitive and physical characteristics of the intended user. In other words, perceivability cannot be implemented through visual stimuli for someone who has no vision; mapping does not help someone whose limited ability of abstraction does not allow them to recognize the relation between an abstract representation and the phenomenon this represents; or a joystick's affordance to be wrapped around by fingers is useless to users who have fingerless limbs. If there is a mismatch between the user's characteristics and the way in which design principles are implemented, usability and user experience goals simply cannot be achieved. In other words, the extent to which an interface is, for example, easy to learn and effective to use primarily depends on whether the implementation of design principles conforms to the user's characteristics to which the principles are relevant (e.g. perceivability and sensory characteristics).

Interaction design principles and canine users

When it comes to canine users, the implementation of design principles needs to take into account, as a baseline, their sensory, cognitive and physical capabilities, and the behavioral propensities that derive from those. For example, in terms of perceivability, dogs' dichromatic vision means that they can easily discriminate between blue and yellow, but not between green and red [20]; the comparatively lower resolution in their light perception may significantly impact on the way they see digital objects; on the other hand, their extraordinary olfactory capabilities [7] are bound to play an important role in their perception of physical objects; their wider acoustic range [10] means that background noise produced by any device may interfere with a dogs' perceptual experience without the designer's awareness. In terms of consistency, compared to adult humans, dogs' preference for size and texture as categorization parameters [29] means that differences in shape, often used in human interfaces, are comparatively less helpful for canine users. Also, dogs' lower abstraction capabilities mean that variations between controls that have the same function can cause a great deal of confusion. The same considerations apply when considering feedback, where space-temporal distance between input and feedback output can significantly affect its effectiveness. In terms of affordance, major morphological differences between humans and dogs, such as the fact that the latter are quadruped and have limited limb dexterity, mean that they are more likely to investigate and interact with objects using their snout, which carries an extremely sensitive sensor (i.e. their nose) [13]; on the other hand, the sensitivity of this sensor needs to be taken into account if dogs are expected to interact with objects using their snouts.

Interaction design principles in ACI research

ACI researchers have implicitly or explicitly accounted for at least some design principles and canine capabilities in species-specific implementations. For example, Zeagler *et al.* [30] explicitly considered canine perceivability when training dogs to perform touchscreen-based tasks using as targets blue and yellow virtual objects, at least for what concerns color vision. In this respect, Hirskyj-Douglas *et al.* [8] discusses canine perception and its implications for the design of video entertainment for dogs, providing insights into the possible appropriateness of digital interfaces for canine users. In Resner's [25] principled approach to the design of a human-canine remote communication system's canine affordance was one of the main considerations. Jackson *et al.* [9]'s sensor-enhanced canine vest enabling search and rescue dogs to communicate with their handler by biting on an ergonomically designed pulley offered good affordance to the user. A similar approach was taken by Robinson *et al.* [27]'s design of a canine alarm for diabetes alert dogs, whereby interchangeable pulleys were used explicitly to address the issue of affordance for dogs of different ages, skills, levels of energy and body sizes. Zeagler *et al.* [30]'s choice of touchscreen, enabling snout interaction, is informed by their consideration of canine affordance. Mancini *et al.* [13]'s interface for cancer detection dogs affords spontaneous snout interaction as an indicator of the presence of volatiles from cancer cells in biological samples. The need to provide dogs with appropriate feedback was explicitly accounted for by Resner [25]'s human-canine communication system. This was a critical issue in Robinson *et al.* [26]'s design of an alarm for medical alert dogs, where the time lapsed between the dog's input (i.e. triggering the alarm) and the outcome (i.e. help arriving on the scene) could be significantly long. The problem of feedback latency and its impact on dogs' learning during training was directly addressed by Majikes *et al.* [12]'s haptic vest in a bid to increase the effectiveness of training protocols.

These applications tend to, directly or indirectly, address design aspects that pertain to specific interaction design principles. We are interested in how multiple design principles could, or fail to, be simultaneously implemented in interfaces that animals (here mobility assistance dogs) come across in human environments. On the one hand, we are concerned with the accessibility of built environments to more-than-human users; we consider the extent to which such pre-existing environments (do not) conform to canine users' characteristics, how this (non-)conformity challenges the dogs and what could be done to make them more accessible for them. On the other hand, we are interested in understanding which of the design principles that are applied in interaction design might be more relevant when designing for animals (here dogs).

UNDERSTANDING THE CHALLENGES

Early explorations

Our research on this topic started with a workshop on more-than-human participatory research [17] in collaboration with Dogs for Good (formerly Dogs for the Disabled), a leading UK Charity for the training and matching of mobility assistance dogs. During the workshop it quickly became clear how the interfaces that mobility assistance dogs are required to learn to use and operate on a daily basis fail to adhere to even the most basic interaction design principles, if considered in terms of canine characteristics. For example, red and green, the colors that dogs struggle to see, are often used to signal either opposite functions (e.g. access vs no-access) or functions with opposite meaning (e.g. safety vs danger), whereby the color is often the only distinguishing feature between two controls. There is a wide stylistic variety between controls that do the same thing (e.g. light switches) or that need to be engages with in the same way (e.g. by pressing). Controls are often very small, positioned well above the height of a dog and they require too much precision, pressure and dexterity to be operated by fingerless paws. These findings prompted us to begin to experiment with designs that would conform to interaction design principles, consistent with canine characteristics.

Ethnographic study

To better understand the extent to which mobility assistance dogs are challenged and affected by human environments, we later conducted an ethnographic study at the facilities of Dogs for Good, the findings of which are reported here. The study lasted for a week, during which we investigated how dogs become mobility assistants, what kind of training they undergo, what difficulties they encounter, and how they and their performance are affected as a consequence. A number of staff took part in the study, including 6 trainers and the dogs they worked with, and representatives of different team in the organization. All trainers were highly qualified animal behavioral experts with each over 10 years experience in the field, and we relied on their expertise to interpret the dogs' behavior. We observed their work and followed their conversations, carrying out contextual and semi-structured interviews. We audio or video recorded the sessions, and took notes, as appropriate, analyzing videos, audios and notes to extract recurring and salient themes.

Findings

Raising and caring for the dogs. At this particular Charity, it generally takes about two years for an assistance dog to qualify. From selecting puppies to matching dogs with clients, the raising and training process is highly complex, carefully structured, and resource intensive, requiring the close collaboration of several teams. The *selection team* manages a careful breeding program, closely following the puppies for their first 8 weeks of age. The *socialization team* closely liaises with carefully selected socializers who care for and develop the puppies' confidence in different environments until they are ready to start training at around 18 months of age. The *training team* then carries out essential training for about 20 weeks following standard protocols tailored to individual dogs, and assessing them at given intervals. The *instructor team* then matches each dog with a suitable client, carrying out advanced training tailored to the client's needs for a further 8 weeks. The *kennel team* takes care for the dogs when they stay at the facility's kennels during training. Finally, the *after-care team* provides support for the new pair once they start living together.

The dogs' welfare is of paramount importance to the Charity and the staff makes every effort to ensure the dogs' wellbeing and comfort. To this effect, the kennels are designed to maximize the welfare of the dogs, and everything about the dogs, from their diet to their outings, is meticulously recorded. If any dog shows sign of stress or anxiety by being housed in kennels, they are taken home by a volunteer at the end of the working day, instead of staying on-site. Any dog can be withdrawn from training at any stage for whatever reason; withdrawn dogs can have alternative careers and work as demonstration dogs or are re-homed as a family dog. Finally, the Charity grants a license to the client to use the dog during their working life with the Charity, always retaining overall ownership of the dog.

Training tasks and methods. All dogs placed by Dogs for Good are accredited through Assistance Dogs International. Training is the most significant part during the process. It happens through positive reinforcement (i.e. rewarding desired behaviors to encourage their recurrence), initially associating small food rewards to the sound of a clicker and subsequently using the clicker to mark desired behavior as it occurs, thus gradually shaping it. In this process, marking timeliness is essential and the quality of food rewards is chosen proportionally to the difficulty of the task (i.e. the harder the task the more appetising the reward).

The dogs go through *essential* (20 weeks), and *advanced* (8 weeks) *training*. Essential training requirements include: walking on a lose lead, in a safe and relaxed manner next to a mobility aid (normally on the left side since humans are mostly right-handed); being confident in different environments, without being distracted by sounds (traffic, crowd, etc.), smells (food, garbage, etc.), and other creatures (children, cats, birds, etc.); coming back upon recall in any situation, such as after having an enjoyable time in a park. The dogs are also taught specific commands including: push (to operate switches); pull (to open doors, or to take off clothes); retrieve (to pick up the things); speak (i.e. bark, normally not encouraged, unless the clients have specific needs). Advanced training requirements vary depending on the needs of the client, which might include using the lift, operating small buttons, taking a bus, or going to church. Training contents are increasingly upgraded as the training progresses. Initially, the dogs are given time to understand their roles through light training, while the trainers work at gaining the dogs' trust. Each training item (e.g. operating a switch) is tackled in stages, with the dogs always moving from the easier to the more difficult stages (e.g. from an easy switch to a difficult one). As pointed out by the trainers, all dogs are different and experience individual difficulties (e.g. some might find it hard to retrieve, others might be afraid of taking a lift), which are assessed and addressed by the trainers.

Training settings vary from the Charity's newly built training home (a model of a real home) to fields, rail stations, retail parks, residential areas, and so on. Equally, training equipment varies widely. In addition to clicker and treats, each trainer uses a range of objects, such as target boards to teach the dogs to target access buttons and light switches; rope cords tied to door handles that the dogs need to learn to pull to open the doors; things such as toys, keys and phone models for the dogs to learn to pick up; furniture models, such as washing machines, and controls such as switches for them to learn to interact with; clothes for them to learn to undress a person; mobility aids, such as battery operated wheelchairs. The trainers endeavour to expose the dogs to as many scenarios as possible, making it as pleasant for the dogs as they can, but they also train the dogs to be comfortable with doing nothing. Generally they emphasized that they "*want them to be working because they enjoy it, and we want it to be as stress free, as happy as possible*".

Switches training. While the dogs are trained in a variety of tasks, to illustrate the challenges they encounter in human environments, here we focus on switches training. Operating switches, such as access or light buttons, is very demanding in an assistance dog's work. The training strategy is teaching the dogs to see where the button is and then use their paws to push it, with confidence and accuracy. This includes the following steps: 1) trainers start training the dogs with a wooden target board to let them get used to putting their paws on it while it is on the floor; 2) trainers move the target board to different places (up on a wall, on a step, or on a chair), in order to get the dogs used to jumping up or moving around, putting their feet on different textures, etc.; 3) trainers put the target board onto real buttons; 4) trainers may gradually reduce the size of the board or if the dog advances well, remove the target board, and let the dogs push the real buttons. To help the dogs, trainers take it very slowly and use social clues like eye gazing or gestures to help the dogs focus where they are asking them to push. Scratches in the areas surrounding the switches are typical and signal failed attempts, providing an indication of the difficulty of the task.

The training home is equipped with switches in different materials and sizes, as illustrated in Figure 1, including: a white plastic board which can be stuck at different heights (Fig. 1.a), a large plastic light button (Fig. 1.b), a small plastic light button (Fig. 1.c), a small metal access button (Fig. 1.d), a small metal access button placed at a lower position (Fig. 1.e). Conferring with one another during a session, trainers commented that 'switch' 1.*a* is confusing for some dogs possibly because "*they don't understand what it is for*"; for essential training they mostly use switch 1.*b* because it is big, protruding and placed at an easily reachable height. Furthermore, trainers reported that they normally only introduce switch 1.*c* towards the end of essential training and leave the switch 1.*d* and switch 1.*e* for advanced training, if required, because they are either "*too small*" or "*too flat for the dogs to see and target*", and because "*metal buttons are too hard to push*".

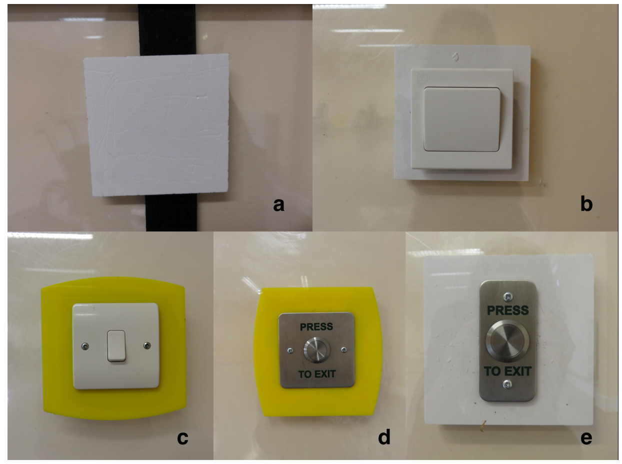

Figure 1: The on-site switches

In spite of a meticolous training protocol, some dogs find learning to operate switches hard. For example, during an on-site training session, a dog was moving from the wooden target board to the 'switch' 1.*a*. After briefly practicing with the target board on the floor, his trainer started moving the board around. Every time the board moved to a new place, the dog tried to sniff or bite it, and it took several attempts before he could push it with his paws (Fig. 2.c). The dog was then introduced to the white plastic board of 'switch' 1.*a*. When the board was placed on a step, it appeared as though the dog was trying to figure out which action could get him the food reward by trying different things, and eventually succeeding (Fig. 2.d). However, when the trainer stuck the board back on the wall, the dog looked confused and only tentatively touched it with his nose (Fig. 2.e). As he refused to go further with 'switch' 1.*a*, the trainer replaced the white plastic board with the wooden target board, which he could eventually push (Fig. 2.g). The trainer explained that the dog was confused by the frame around and black strip behind 'switch' 1.*a*, and that this was "*too much for him to take in a single session*" (Fig. 2.e.g).

As mentioned above, training happens off-site as well as on-site. Off-site switches are normally access buttons found in places such as banks and shops. The trainers pointed out that with repeated exposure, the dogs get better at operating those buttons, in that they learn to recognise where the buttons are and how to push them. This also happens once the dogs start working for the clients because they are likely to repeatedly visit the same places and use the same buttons. However, generally off-site switches appeared significantly more challenging. For example, one of the switches we encountered during one session was a big round access button on a brick wall outside a bank (Fig. 3.a,b,c). The trainers explained that the dogs cold use the wall as a support when jumping up to push the button; at the same time the background enabled the dog to see the switch clearly. However, another big round access button inside the bank was on a metal pillar (Fig. 3.d) and therefore there was nowhere for the dogs to jump up to for support. Additionally the trainer explained that "*some dogs don't like touching metal*". Another switch was a big square access button outside a shop (Fig. 3.e). It was a lot lower than the other switches, so for big dogs it was harder to jump up to with precision. It was also sticking out against transparent glass, so the whole presentation was quite different from the other switches and, according to the trainer, confusing for the dogs. Additionally, the button was harder and we observed that the dogs needed to hit it couple of times to activate it.

Figure 2: Training with on-site switches

According to the trainers, the issues that we observed and that made it challenging for the dogs to operate the switches negatively affected the welfare and the confidence of the dogs. They pointed out how, during their training and working lives, assistance dogs repetitively perform unnatural actions, which can have a negative impact on their health. For instance "*if they are jumping up a lot on their back legs, their hips and knees…in a repeated way, frequently…cause they are big dogs and they are heavy, there is a chance they could wound…*". Such occupational injuries clearly raise ethical concerns and highlight a need for better tools. Trainers and instructors also emphasized how building and maintaining confidence is one of the most important things for an assistance dog, from their early socialization all the way to their advanced training. They explained how the training methods focus on making the dogs enjoy their work and feel confident with what they are doing; the dogs are never forced to do things that are too difficult for them. However, according to both trainers and instructors, such carefully built confidence can easily be affected when, due to the interaction challenges they face, the dogs fail their tasks; for example: "*…confusion affects their confidence and they lose motivation if they have to repeat actions without understanding what they are doing*".

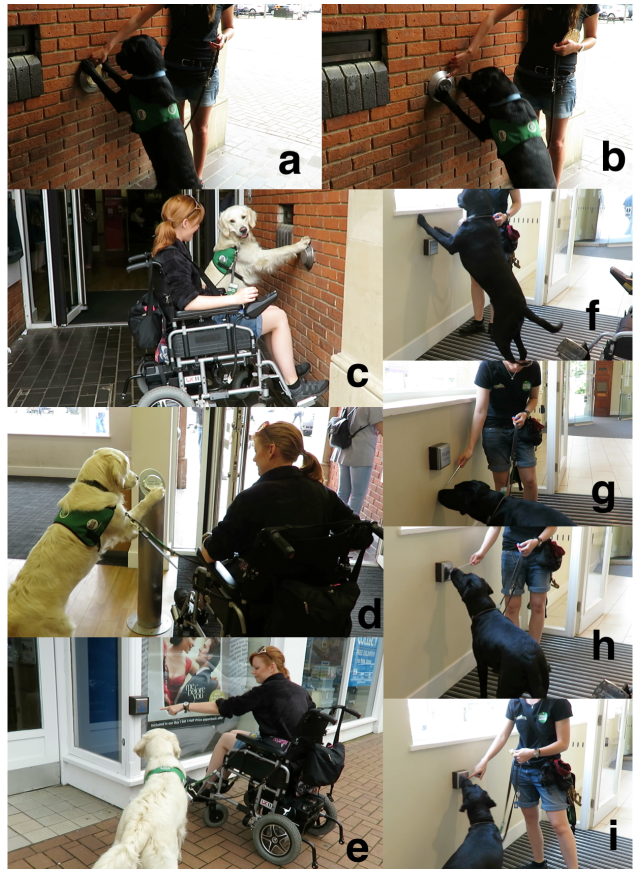

Figure 3: Training with off-site switches

Highlights. Overall, trainers and instructors highlighted the following points (the notations in parentheses are ours):

- Small controls such as light switches increase the chance of non activation, particularly if they do not stand out. The bigger and more obvious a button the easier it is for the dog to see and target it. (*perception, affordance*)
- There is no one-height-fits-all, because dogs vary in size. Jumping up impacts the dogs' hips and back legs. The more accessible to the dogs' nose the better, since head movements are less constrained and more accurate, and joint impact is avoided. (*affordance*)
- Hard, slippery materials such as metal, especially associated with 'tight' mechanisms behind flat buttons, make it difficult for the dogs to push. An unpleasant material might stop the dogs from trying. (*affordance, perception*)
- Transparent and reflective backgrounds can make the dogs feel insecure. Background provides support if the dogs need to jump up and if it contrasts with the button it makes this more clearly visible. (*affordance, perception*)
- Lack of context, when there is no direct feedback for an interaction, can confuse the dogs, as they do not understand what they are doing. If they understand the

effect of their actions, their performance is more likely to improve. (*feedback*)

- Dealing with switches of different shapes and sizes is confusing for dogs. It would be preferable for switches in either public or private places to be the same. (*consistency*)

ADDRESSING THE CHALLENGES

Early prototypes

Aiming to provide mobility assistance dogs with better working tools whilst furthering our understanding of their requirements, we explored the systematic implementation of interaction design principles in conformity with the characteristics of canine users, to produce early prototypes of canine-friendly switches. Our prototypes were 3D printed from plastic and were composed of two halves, a base and a lid; the two halves were clicked together but kept apart by four inner springs; encased in a slot inside the center of the base was a spring switch that closed an electric circuit when the lid was pressed towards the base. The switch accounted for design principles conform to canine characteristics in the following way: they were either bright blue or bright yellow; were all large in size and square in shape, but in three different sizes (20cmx20cm, 15cmx15cm, 10cmx10cm); different colors and sizes aimed to denote different functions; the switches were very sensitive to the touch and reliably activated wherever touched on the lid; their surface was slightly textured to provide gentle grip. We produced a wired and a rudimentary wireless version, which could be positioned where appropriate (although for our early evaluation we used the wired version). The lid was protruding enough to clearly provide a sense of movement when pressed and the spring switch produced a clicking noise; however, at this stage there was no other feedback mechanism, and we mostly relied on system outcome as a form of feedback. The purpose of these early prototypes was to enable us to evaluate a proof of concept and to further develop our canine friendly designs.

Evaluation in use: a case of requested deployment

As a first form of evaluation, we installed some of the switches in one of the buildings on our University campus, to enable PhD student Helen, who is affected by MS, and her mobility assistance dog Ellie to independently access the building. Helen had commented how: "*When I have to carry my books and have to handle my crutches and hold on to Ellie at the same time, it is really difficult to enter the building…there is a lot of variation across the campus and even in the same building between, say, access buttons…Ellie is faced with three different access buttons in the space of just twenty meters, which is very confusing…one of the buttons is not too bad for her, but the others are quite difficult…*".

We installed four switches for Ellie, two blue ones to open two security doors she and Helen were regularly using to access Helen's office, and two yellow switches to operate the neon lights near Helen's desk. Motors were installed onto the doors so they would open automatically when the switches were pressed and automatically close again; this meant that the switch only needed to trigger an 'on' function. However, for the lights we needed an 'on' and an 'off' function; instead of installing two separate switches for separate functions, we modified the inner mechanism of our switch to enable both. This resulted in more protruding and harder to press buttons. All the switches were installed at the height of Ellie's snout. The switches have been in place and in use for nearly a year, during which we have kept in touch with Helen, before conducting a formal contextual interview about her and Ellie's experience, also recording Ellie's performance.

Figure 4. Ellie activating the door opening switch

Findings

Helen reported how the blue switches operating the doors have made a significant difference for Ellie, and consequently for herself. Indeed, from our observations she appeared to be able to operate them with ease using her nose (Fig. 4) and she seemed to do so with confidence, smoothly hitting the target with no sign of hesitation in her body language. Around the switches themselves there was little evidence of scratches that may indicate failed attempts to engage with the interface. This might be due to the *strong contrast with the background* presented by the blue switches, which likely made them highly perceivable for Ellie thus guiding her towards them; to the switches' *large size* and *consistent sensitivity to the touch* throughout the period, which might have enabled Ellie to easily target the switches, and reliably and comfortably operate them with her snout; and to the *consistently prompt response of the doors* upon activation, which might have worked as an obvious form of feedback to her interaction.

On the other hand, Helen reported that Ellie had problems learning and using the yellow switches. Indeed, the area around the yellow switches carries many scratching marks, a clear sign of many failed attempts at engaging with the device. As possible explanations, we noted that, once installed on the cream wall, the switches did not significantly contrast with the background and therefore might have been less perceivable. More significantly, Helen reported how the fact that the switches were harder to press and their activation less consistent was confusing for Ellie. Additionally, the fact that the switches activated neon lights meant that there was a delay between Ellie's input and the outcome of her interaction. Also, the output source was on the ceiling, far away from the input device; given that no other feedback was provided, this delay was likely a significant part of the problem. According to Helen, the fact that Ellie and she use the building only once a week further aggravated these issues, because Ellie did not have the chance to train as much as she would have needed to in order to learn and remember how to use a more challenging interface.

Evaluation in training: a case of spontaneous adoption

In addition to the longitudinal evaluation discussed above, we are now preparing to run controlled trials at Dogs for Good. However, during a recent visit to the training center we discovered that one of the trainers had already started to use our switches in her classes out of curiosity, having come across one of the prototypes in her managers' office.

Findings

The trainer commented: "*I would love to have more tools like this, it is brilliant for training…It would be lovely to have all switches like this one.*" In particular, the trainer reported how: 1) the lightly rough texture of the switch's surface "*gives the dogs a better feel under their paws, compared with the wooden target board*"; 2) the movement of the switch's lid under the pressure of a paw or snout "*gives the dogs a real feeling of pushing down an object, which provides a better feedback than the flat wooden target board and most of the small human switches*" the dogs are usually trained on; 3) the clicking sound resulting from the activation of the switch "*makes the dogs aware that they have achieved something*"; 4) "*it is a real switch and also a portable object*" that the trainer could use both on-site and off-site, and position on the ground or on the wall. The trainer also emphasized how the switch made the 'push training' easier for the dogs who were less confident.

DISCUSSION

The need for accessible working environments

We have seen how the process of raising, training and matching a mobility assistance dog is long, complex and resource-intensive; and how much is invested into selecting the dogs, understanding and meeting their individual needs, and forming them as well-rounded and effective assistant companions. On the other hand, our findings show how the environments that mobility assistance dogs are required to learn to work in challenge their learning abilities and confidence as well as their welfare as workers. The human interfaces that the dogs have to interact with fail to adhere to basic design principles in terms of canine sensory, cognitive and physical characteristics, thus providing poor usability and user experience for them. Shortcomings with respect to usability aspects, such as learnability or efficiency, or user experience aspects, such as motivation or satisfaction, have clear consequences. For example, poor learnability leads to interaction failures, which undermine the dogs' confidence, reducing their motivation and further slowing down the learning process. It is therefore plausible that the greater the interaction obstacles to the dogs' learning and performance, the longer the training time and the greater the risk that trainees may not qualify or that potential training candidates may not be selected in the first place, due to the demanding nature of the job. The dogs who qualify continue to work in challenging environments, which affects the efficiency and effectiveness of their work, and of course increases the chances of interaction errors, as it would happen with any human expected to operate in what could be referred to as a non-accessible *interaction environments*. Furthermore, in the long run, the ongoing repetition of behaviors that are inconsistent with the dogs' evolutionary characteristics (e.g. balancing their whole body weight on their rear legs whilst attempting to hit a small target with front limbs that lack fine motor control) is bound to affect their welfare over time. Resulting health issues could be compared to problems such as repetitive strain injury in humans, which can be severely debilitating. Such problems highlight the need to provide mobility assistance dogs with more accessible working environments that can provide better usability and user experience.

A multispecies view of interaction design principles

The findings of our prototypes' early evaluations suggest that interactive devices whose design adheres to basic design principles implemented consistently with canine sensory, cognitive and physical characteristics (e.g. blue switch), have the potential to provide better usability and experience for canine users. Conversely, those that fail to adhere to such principles in accord to canine characteristics (e.g. yellow switch) are likely to provide poorer usability and experience. While principles typically referred to in interaction design include perceivability, consistency, mapping, affordance, constraints and feedback, from our findings only four of these principles emerge as relevant: perceivability, consistency, affordance and feedback. This might be due to the comparative simplicity of the interactions the dogs are trained to perform, but it might also be that these four principles are in fact more relevant than others when designing interactions for other species.

In a previous study of technology-mediated dog-tracking practices [15], we discussed interspecies sensemaking with reference to three possible types of sign: icons, whose relation to the referent is based on degrees of similarity (e.g. a drawing or picture); symbols, whose relation to the referent is entirely arbitrary (e.g. a word or mathematical formula); indexes, whose relation to the referent is based on contiguity (e.g. a footprint or smell). We discussed how: 1) iconic communication requires similar abilities of abstraction between interlocutors, which between different species cannot be assumed; 2) symbolic communication requires the ability to learn arbitrary associations between conventional signs and their meaning, which with some species can be achieved through training; 3) indexical communication only requires the ability to recognize non-arbitrary associations between co-occurring phenomena, which just about any species has evolved, in order to make sense of and survive in their environment. Because of their non-arbitrary and contiguous nature, indexical associations are the most reliable and trustworthy (e.g. this is why dogs pay more attention to our body language than they do to our utterances; as it is hard to control, body language more reliably indicates our emotions and intentions, whereas words can lie). Non-arbitrary and contiguous associations are highly consistent and characterized by space-temporal proximity between associated phenomena (i.e. a sign and its meaning). The more symbolic associations 'behave' like indexical associations, the more reliable and trustworthy they appear, and the easier they are to learn.

These considerations have implications when designing interactions for animal users (in this case dogs). Generally speaking, interactions that capitalize on animals' capacity to recognize indexical associations are more likely to be accessible to animal users, compared for example to interactions that rely on iconic associations. Similarly, interaction design principles that reflect the characteristics of indexical associations are arguably more universally relevant. In this respect, ***consistency*** is critical to enable any user to establish associations in space (e.g. all the square blue buttons next to doors around the house open the doors) and time (e.g. every time a square blue button is pushed the door next to it opens). When consistently associated with an input and when provided in space-temporal proximity (i.e. immediately after and near to the input location), ***feedback*** works as an index that a certain function has been triggered (e.g. a button lighting up when activated). As a form of consistency between the morphological characteristics of the user and those of an interface, ***affordance*** indicates a potential for interaction; it is the equivalent of a footprint showing, not where a foot has been, but where a foot can go (here we refer to physical affordance rather than virtual affordance, since the latter implies the ability to perceive and interpret iconic abstractions). Finally, for the elements of an interface to signal anything (and for any interaction to be even possible), these need to be perceivable; thus ***perceivability*** is arguably the most basic principle.

On the other hand, *mapping* relies on what are essentially iconic associations between an abstract representation and the phenomenon being represented (e.g. a volume bar used to represent volume variations); this assumes that the user can model (abstract) the phenomenon in question in the same way, which is difficult to assume when designing for other species; thus mapping might not be as relevant or useful as the principles discussed above. *Constraints* modulates 'layered' functions (e.g. actions are enabled or disabled at different points during a task); it assumes that the user understands such modulations without experiencing it as inconsistency; thus constraints might also not be as helpful as other principles when designing for other species (unless the resulting cognitive challenges were integral part of the user experience, such as in games).

Future work could empirically investigate the above hypotheses in order to establish a hierarchy of interaction design principles from a multispecies perspective. Future work could also investigate how such a hierarchy of principles can inform a range of interaction design solutions that are compatible with canine (or others') sensory, cognitive and physical characteristics and at the same time sufficiently diverse to account for the variety of functions that mobility assistance dogs (or others) need to operate.

Envisioning multispecies worlds

There is currently a stark contrast between how important the role of mobility assistance dogs is in human society and how little the environments they are required to interact with on a daily basis meet their requirements as users and workers. In the UK the number of registered assistance dogs is in the thousands [2] and in the US is in the hundreds of thousands [19], and numbers are only set to increase in coming years following a growing demand. Mobility assistance dogs are an active part of modern society and thus are entitled, we argue, to working in environments that acknowledge and reflect who they are. On the other hand, due precisely to the pervasiveness of their work and the variety of environments in which they operate, properly accommodating these users would require negotiating significant tensions between what might be ideal solutions and the investment required to achieve such solutions. The commitment with which these tensions might be considered and negotiated is arguably an expression of how truly inclusive our society is when it comes to supporting those who support us.

While in the shorter term it is more realistic to identify effective but economic solutions, such as wireless switches and other controls, which are portable and can be easily retrofitted onto existing infrastructures, we suggest that there is a need to think beyond single applications aimed at alleviating specific environmental circumstances, taking a more systemic approach. We need to envision multispecies worlds in which technology meets the needs of all those who inhabit them, and to let such visions guide our work, as we address the challenges we encounter along the way. Furthermore, addressing the design challenges exemplified by the role of mobility assistant dogs has the potential to benefit not only dogs, but also billions of farm, laboratory, zoo or companion animals whose evolutionary capacities, needs and preferences are yet to be reflected in increasingly technologized human environments they have not designed nor chosen to live in [14]. Addressing this *environmental disparity* is a responsibility for human society and an opportunity for ACI as a developing discipline.

CONCLUSIONS

Mobility assistance dogs play an invaluable role in society and are in increasing demand. Our ethnography of a leading training facility, has explored the usability and experience challenges faced by these dogs, and the impact that such challenges can have on their learning and welfare. Our preliminary evaluations of canine-friendly switches show how the application of interaction design principles in conformity with canine sensory, cognitive and physical characteristics can inform the design of environmental interfaces that meet the requirements of canine users. Early empirical data and an analysis of interaction design principles in terms of multispecies sensemaking mechanisms, highlights how some principles are especially relevant when designing for other species. Further research should further test the relevance and relative importance of different principles and explore how their application could enable the development of environmental interfaces that meet canine requirements while supporting a sufficiently wide range of functionalities.

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